Subacute ruminal acidosis in dairy cows - physiological background, risk factors and diagnostic methods

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Abstract

According to the latest studies, the prevalence of **subacute ruminal acidosis (SARA)** is around 20% in early and mid-lactation dairy cows, generating annual losses in the United States of approximately USD 500 million to 1 billion. The diagnosis of SARA is still difficult due to lack of pathognomonic clues and the delayed appearance of certain clinical signs. Therefore, SARA remains neglected or even unrecognized in many dairy herds. SARA is characterized by daily episodes of low ruminal pH, when the pH remains in the range of 5.2 to 6 for a prolonged period due to the accumulation of short-chain fatty acids and insufficient rumen buffering. The causes of SARA are related to high-grain diets, such as feeding excessive amounts of non-structural carbohydrates and highly fermentable forages, and insufficient dietary coarse fibre. SARA is associated with the inflammation of several organs and tissues in dairy cows, and its main long-term health and economic consequences are the fluctuation of feed intake, reduced fibre digestion, depression of milk yield and milk fat content, gastrointestinal damage, diarrhoea, laminitis, liver abscesses, and lameness. The aim of this review is to summarize the information available on the physiological aspects, risk factors, prevalence and possible indicators of SARA in dairy cattle. Based on the existing literature, rumenocentesis and the use of an oral stomach tube are reliable field techniques to detect SARA. Nowadays, improved field techniques allowing the continuous measurement of reticuloruminal pH are also available for better diagnosis of SARA. Wireless indwelling pH probes may become important tools for the continuous measurement of ruminal pH in the coming years.

Key words: *subacute ruminal acidosis; diagnosis; rumenocentesis; indwelling intraruminal sensor; dairy cattle*

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Introduction

As one of the most common metabolic disorders in high-yielding dairy cows kept in intensive livestock production systems (Krause and Oetzel, 2006; Kleen et al., 2013), **subacute ruminal acidosis (SARA)** has negative effects on the performance and health of dairy cows. Garret et al. (1997) reported that up to 19% of early lactation and 26% of mid-lactation dairy cows in the US have SARA. Given this relatively high prevalence, this metabolic disorder generates annual losses of approximately USD 500 million to 1 billion (Enemark, 2008).

Therefore, cow nutritional requirements are fast becoming a key issue, since diets fulfilling energy intake but not the fibre requirement of high-yielding cows may enhance the risk of SARA (Krause and Oetzel, 2006; Oetzel, 2007). Diets with high energy density are rich in starch, and bacterial digestion of this highly fermentable ingredient result in the greater production of volatile fatty acids (**VFA**) in the rumen. Elevated VFA concentrations generate a higher acid load of the forestomach. Elevated ruminal pH induces pronounced changes in the intra-ruminal ecosystems, while changes in the microbe community (Enemark et al., 2002; Oetzel, 2007; Mulligan and Doherty, 2008) may decrease milk production and cause significant economic losses (Hobson and Stewart, 1997; Oetzel, 2007; Calsamiglia et al., 2012).

As SARA is a gateway condition that may predispose the animals to develop other metabolic disorders or diseases such as laminitis, ruminitis, liver abscesses and posterior vena caval syndrome (Nordlund, 2003a,b; Oetzel, 2004), it is a matter of concern for animal welfare and herd profitability, especially in well-managed dairy herds (Kleen et al., 2013; Plaizier et al., 2014). For this reason, cows should be regularly monitored to detect SARA (Abdela, 2016).

The diagnosis of SARA is a complex challenge. Although it is still debatable whether SARA is a pH-related problem (Calsamiglia et al., 2012), the field assessment of reticuloruminal pH gives opportunities for health monitoring at the herd level (Gasteiner et al., 2009). In addition to discussing the physiological origin of SARA, this review provides information on the prevalence, risk factors, and indicators of this problem by providing an extensive overview of the evolution of diagnostic approaches.

The rumen and its pH

Ruminal digestion, ruminal microbiota and mucosa

The ruminal environment is a complex ecosystem. The diverse ruminal microbiota consists of protozoa, fungi and bacteria. The presence of bacteria and other microorganisms in the rumen depends on the presence of microorganisms in the animal's environment, including feed (Hobson and Stewart, 1988). Rumen bacteria are responsible for the fermentation of plant fibre components, carbohydrates to transform these to VFA, and lactic acid, carbon dioxide, ammonia and methane as by-products. In addition to bacteria, the rumen contains a population of mixed genera and species of anaerobic protozoa in numbers up to about 10^6 ml^{-1}. Protozoa mainly consume bacteria for supplying nitrogenous compounds for growth (Hobson and Stewart, 1988). The rate of bacterial uptake is very pH sensitive with an optimum at pH 6.0, falling off to zero at pH 5.0 and 75% at pH 7.0 and 30% at pH 8.0 (Coleman, 1967). For example, due to feeding on large amounts of concentrate, they may disappear from the rumen fluid, which may increase acidosis. Below pH 6, the protozoa population decreases and below pH 5 it completely

disappears from the rumen (Lettat et al., 2010). Ciliate protozoa show an inverse relationship with fungal densities in the rumen. There are predatory and metabolic interactions between these eukaryotic microorganisms. However, in general, the ruminal protozoa and fungi both contribute to fibre breakdown in the rumen (Bird and Leng, 1985). Most rumen fungi produce a wide range of enzymes that can digest most of the structural carbohydrates of plant cell walls (Hobson and Steward, 1988).

Fibre-digesting bacteria also produce lactic acid, and its production depends on the pH of the rumen. In addition to microorganisms, sufficient muscular motility and saliva production and a well-structured rumen mat are also needed for proper rumen function (Hobson and Stewart, 1988). In severe ruminal acidosis, the muscular activity of the organ can be disturbed or become totally inhibited (Russel and Rychlik, 2001).

Since the rumen microbiota is specialized in the fermentation of structural carbohydrates and plays a key role in the absorption of VFA, the ruminal mucosa has special characteristics to fulfil its tasks. It is composed of **stratified squamous epithelium (SSE)**, which has an increased surface area due to the presence of papillae. Papillae are of key importance for the microbial population by creating a surface for attachment and improving the connection between microbial fermentation and ruminal absorption.

Adaptation of the mucosa to an elevated level of cereal grain intake is a key physiological event in dairy cattle. High VFA, in particular butyric acid concentration in the rumen, causes cellular proliferation and morphogenesis of the SSE. Changes in the diet may cause disturbances in mucosal function, which may lead to erosions of the SSE, whereby the microbes and **lipopolysaccharides (LPS)** of Gram-negative bacteria can translocate into the portal bloodstream and later into the systemic circulation.

Ruminal pH and the acid balance

The main source of acidification in the rumen is bacterial metabolism, which produces organic acids (Beauchemin et al., 2003). Along with the acid production of bacteria, acid removal and acid neutralization are needed to maintain the pH within the physiological range. About 30% of the ruminal acid content can be neutralized by buffers, about 53% can be absorbed by the ruminal mucosa, and it can also be utilized by microorganisms (Penner et al., 2011). Salivary buffers, primarily HCO_3^- and $H_2PO_4^-$, help in eliminating acidity to stabilize the pH.

The transition period is very sensitive for dairy cows (Folnožić et al., 2015, 2016). As one of the adaptations of the ruminal mucosa, it absorbs more VFA when VFA production is increasing (Penner et al., 2011). In cases of feeding extreme amounts of concentrate, the Na^+/H^+ exchange activity and the $SCFA^-/HCO_3^-$ (Short-chain fatty acid/bicarbonate) exchange activity are also increased, helping to maintain the pH within its normal range.

Physiological pH varies between 6.2 and 6.8, and in a healthy cow, ruminal pH can vary by 2.5 pH points throughout the day (Gasteiner et al., 2009). The decrease in ruminal pH appears to result from the accumulation of VFA and lactic acid (Krause and Oetzel, 2006) and insufficient rumen buffering (Abdela, 2016). Rumen pH below 6 enhances the development of amylolytic bacteria (e.g. lactate-producing bacteria) and changes the digestibility of **neutral detergent fibre (NDF)** and the population of cellulolytic bacteria (Mackie and Gilchrist, 1979). The drop of pH from 6.0 to 5.5 is mainly due to the overproduction and accumulation of butyric acid, whereas the accumulation of propionic acid creates more serious acidosis with a pH around 5.5–5.0

(Guatteo, 2013). A pH of 5.8 (when the balancing of lactate production is started by lactate-utilizing bacteria) is the first threshold of the fermentative pattern with an increased propionate/butyrate ratio, and usually the first pathological consequences of acidosis appear here (Abdela et al., 2016). For instance, the early inflammatory response in the rumen appears when the ruminal pH drops below pH 5.6 for more than 1 h (Gozho et al., 2005). Between pH 5.5 and 5, *Streptococcus bovis* grows to higher proportions because as nutrients are available following the die-off of other bacteria, and the rate of production of lactic acid exceeds the rate of its removal. When the pH drops below 5.1, both the transport and the barrier functions of the rumen epithelium deteriorate. At that stage, obvious signs of acidosis become apparent (Abdela et al., 2016).

Effect of feeding on daily patterns of ruminal pH

The ruminal pH pattern of a cow fed in the classic system (twice a day) shows a two-phase curve with a pH decrease after feeding. The pH reaches its lowest value 2 to 4 h after feeding and increases continuously until the next feeding (Gasteiner et al., 2015). The post-feeding pH drop is the consequence of the sudden abundance of nutrients, as the digestive activity of the microbiota produces acidity during fermentation and saliva is not produced in sufficient quantities (normally 200-250 l/day) to compensate for that acidity (Gasteiner et al., 2009).

Each feeding method has a typical pH pattern. Continuous *ad libitum* hay feeding is characterized by a more stable but higher average pH (mean pH 6.5/ nadir pH 6.14). The more frequent intake of small portions of efficient, structural fibres promotes saliva production and provides a more even distribution of feed intake, therefore rumination can result in a more stable pH close to the physiological range (Gasteiner et al., 2009). Grazing reduces the pH, as pasture grasses are rich in energy, while forage feeding due to higher saliva production slightly increases the pH during the night, resulting in the highest pH value before grazing on pasture the next morning (mean pH 6.36/nadir pH 5.34). Concentrate feeding results in more distinct pH changes with a lower average pH (Steele et al., 2011). The diets of farms with robotic milking result in a very different ruminal pH pattern. Indeed, frequent feeding of small portions of concentrate together with milking reduces the pH variation and limits its drop under pH 6 (Mottram, 2016).

Subacute ruminal acidosis

The definition of SARA

There is no general agreement in the literature on the precise definition of SARA, but it is generally agreed that SARA obviously reflects a low ruminal pH and a syndrome related to impaired ruminal health (Li et al., 2013). All current definitions of SARA are based on the measurement of ruminal pH using various methods. According to Krause and Oetzel (2006), SARA is characterized by daily periods of rumen pH depression below the physiological range, which generally means that the ruminal pH stays in the range of 5.2 to 6 for 2-3 h (Khafipour et al., 2009). Based on another definition, acidosis in cattle means a decrease of base excess in body fluids relative to the acid content (Dehkordi and Dehkordi, 2011). Acute ruminal acidosis, associated with more severe pH depression, higher lactic acid concentration in the rumen digesta and prominent clinical signs (Kleen et al., 2003; Plaizier et al., 2014), is more frequent in feedlots, while SARA not associated with the accumulation of lactic acid in the rumen is more common in dairy herds (Krause and Oetzel, 2006).

The pH threshold of SARA

Based on the literature, it is challenging to set up a specific threshold of rumen pH for defining SARA, since the rumen pH varies between the various locations in the rumen. The highest rumen pH can be observed in the cranial dorsal sac, while the lowest rumen pH is found in the ventral sac and the centre of the solid mat (Duffield et al., 2004; Abdela, 2016).

Thresholds for abnormal pH indicating SARA, according to different authors, should be 5.5, 5.8 and 5.9, when rumen fluid samples are collected by rumenocentesis, through a rumen cannula from the ventral sac (Duffield et al., 2004; Plaizier, 2004). Not only is pH value a diagnostic feature, but the time the cow spends under the critical ruminal pH is also important. More than 176 min per day under pH 5.6 fulfils the criteria for SARA diagnosis (Gozho et al., 2005).

Prevalence and risk factors of SARA

Only limited information is currently available on the prevalence of SARA. Individual cows (Mohammed et al., 2012) and breeds show differences in their sensitivity to SARA, for instance Jersey cows better tolerate grain challenge than Holsteins (Luan et al., 2016).

The risk of developing SARA is highest in primiparous cows (Enemark et al., 2004), in cows grazing or fed with rapidly fermentable low-fibre grass (Li et al., 2013) and in early-lactation cows, due to the instability of their rumen bacterial population (DeVries et al., 2009). Cows in the immediate postpartum period might be at the highest risk for SARA, due to the diminished size and absorptive capacity of rumen papillae after lower-energy diets fed during the dry period (Stone, 2004).

There is a higher risk of SARA in the summer due to heat stress causing lack of ruminal buffering, increased respiratory rate, respiratory alkalosis, and low blood bicarbonate concentrations. Atypical meal patterns (Oetzel, 2007), problems with feed preparation (Leonardi and Armentano, 2003) or with the feeding time-schedule (Kleen et al., 2003) can increase the risk of SARA. Component feeding puts cows at a greater risk of developing SARA than TMR feeding, because animals are at risk of overconsuming concentrates and an increased diurnal variation in rumen pH (Stone, 2004; Gasteiner et al., 2015).

Indicators of SARA

Although it is associated with the inflammation of several organs and tissues, SARA is not a health condition having specific clinical signs (Krause and Oetzel, 2006; Tajik and Nazifi, 2011). Decreased dry matter intake, loss of body condition, alteration of faeces, diarrhoea, milk fat depression, reduced milk yield, rumenitis–caudal vena cava syndrome complex, reduced digestibility of nutrients, gastrointestinal damage, liver abscesses, and lameness are all associated with, but not specific to SARA (Eun et al., 2014). This is an important reason why SARA often remains untreated.

Although some authors have found that laminitis is indicative of a SARA problem in a herd, with prevalence higher than 10% in SARA-affected cows (Nordlund et al., 1995; Enemark et al., 2002), the connection between SARA and laminitis is unknown (Stone, 2004). Diarrhoea has been associated with SARA in dairy herds; however, faecal evaluation (especially faecal pH) has limited value in diagnosing SARA, since faecal pH is not necessarily an indicator of ruminal pH (Abdela, 2016). The faeces are diarrheal, bright, yellowish, has a sweet-sour smell (Guatteo, 2013), is foamy with gas bubbles and contains larger fibre particles 1–2 cm in size (Hall, 2002).

The connection between SARA and milk fat depression is controversial and complex, since the stage of lactation and

the composition of the ration can also affect the milk fat percentage (Enemark et al., 2003). Alterations in the ruminal fermentation pattern due to SARA cause increased absorption of trans-fatty acids, even if the intake of unsaturated fatty acids is not high (Oetzel, 2007). Some of these trans-fatty acids, such as trans-10 C18:1, limit milk fat synthesis, and therefore, SARA is a major cause of milk fat depression (Griinari et al., 1998). Nordlund (2004) suggested that a milk fat percentage below 2.5% in 10% of Holstein is a possible indicator of SARA. In recent case studies, incidence of 8.1% (Xu et al., 2016) or 4.14% milk fat reduction (Danscher et al., 2015) was reported in SARA-affected cows, while other authors did not find milk fat depression in SARA-affected herds (Enjalbert et al., 2008; Tajik et al., 2009) Based on these findings, some authors suggest that the duration of SARA is key, and only long-term SARA affects milk fat content (Oetzel, 2005).

The diagnosis of SARA

One of the most important diagnostic tools for SARA could be the continuous measurement of reticuloruminal pH (Humer et al., 2018a). Measurement of reticuloruminal temperature simultaneously with ruminal pH seems to be useful, since there is a negative correlation between a 39–41 °C reticuloruminal temperature and pH variation within the range of pH 5 and 5.6 during episodes of SARA (Al Zahal et al., 2011). However, low ruminal temperature does not necessarily reflect high ruminal pH because of the possible interferences of water and diet consumption (Gasteiner et al., 2009).

1. Measurement of ruminal fluid samples

Rumen fluid examination has been recommended by several authors as a means of diagnosing SARA, as it gives direct information about the rumen conditions (Duffield et al., 2004; Tajik and Nazifi, 2011). The rumen pH is typically low 5-8 h after TMR feeding and 2-4 h in cases after partially mixed ration feeding (Humer et al., 2018b), and therefore, these are the suggested periods for rumen fluid pH measurement (Beauchemin et al., 2003). Since the applied technique affects the measured pH values, it is important to know which sampling method was used for ruminal fluid collection (Seemann and Spohr, 2007).

1a. Oral–stomach tube technique

As the least invasive method for ruminal fluid collection (Plaizier et al., 2006) the oro-ruminal probe is easily applicable with a suction pump using a 180 cm tube with a cranial-dorsal sampling site and a longer, 200 cm tube with which the ventral rumen can be reached. Because of the substantial risk of saliva contamination of the samples and the pH variability depending on the intraruminal localization of the stomach tube (Enemark et al., 2002), this is not a reliable diagnostic technique for SARA (Abdela, 2016). According to Seemann and Spohr (2007), the stomach tube technique overestimates pH value by about 0.5 pH units, compared to rumenocentesis, therefore discarding the first 200 mL before sampling the required amount of 25-30 mL for pH measurement is recommended (Duffield et al., 2004). As the position of the suction head cannot be fully directed, the fluctuation of pH results depends on operator skill (Sato et al., 2012a). This technique is an impractical method because of animal handling issues (Duffield et al., 2004), moreover, the pH measurement of rumen fluid has limitations as it provides reliable information at the herd level, but not at the individual level (Humer et al., 2018b).

1b. Rumenocentesis

For this method, percutaneous needle aspiration is used for collecting

rumen fluid from the caudoventral rumen by puncturing the rumen through the abdominal wall. As the ventral rumen contains the greatest volume of rumen fluid, puncture is done in the left ventricular rumen (Nordlund et al., 1995). It is performed under local anaesthesia and disinfection, using a 100–120 mm stainless steel needle. With this method, 3-5 mL of ruminal fluid can be collected (Garrett et al., 1997).

This procedure is easily repeatable and requires minimal post-sampling modification of ruminal fluid. It is well tolerated by animals and has no major negative effects on animal health (Bramley et al., 2008). Rumenocentesis is regarded as a better field test in comparison to the oro-ruminal probe, as samples obtained by rumenocentesis are more representative as they are not contaminated with saliva (Duffield et al., 2004). The pH value of rumenocentesis samples is usually about 0.28 lower than the pH value of samples collected through a rumen cannula (Garrett et al., 1997).

Disadvantages are that the surgical procedure requires local anaesthesia, and postoperative complications are possible if the protocol is not followed accurately, such as hematomas, infections and abscesses in almost 60% of the cases at the puncture site (Strabel et al., 2007). Using a small needle, deep local anaesthesia, local disinfection and a small volume of collected sample can help decrease post-puncture complications (Garrett et al., 1999).

1c. Rumen cannulation method

Ruminal cannulation is performed surgically under local anaesthesia and has long been used to measure ruminal pH (Monroe and Perkins, 1939). As the preferred method for research purposes, it was used to validate the location of the stomach probe after oral application (Enemark et al., 2003), to study the variation of pH within the rumen (Duffield et al., 2004), and to evaluate the correlation between different measuring techniques (Al Zahal et al., 2007; Sato et al., 2012b).

During the procedure, the cannula is settled into the fistula to guarantee continuous access to the rumen. The method provides direct access to about all sites of the rumen, guarantees the precise sampling location and enables the collection of large quantities of ruminal content. A disadvantage of the method is that it requires professional skill and the repeated replacement of the cannula cover can disturb the animal and may allow digesta to escape (Tajik and Nazifi, 2011; Abdela, 2016).

Sampling protocols suggest sampling before the morning feeding and 1 to 7 h after feeding (Monroe and Perkins, 1939; Nordlund et al., 1995). To follow the daily pH pattern, multiple measurements should be made at regular intervals (Enemark et al., 2003; Duffield et al., 2004). The ruminal microbiota can alter the physico-chemical characteristics of the ruminal fluid (Aschenbach et al., 2011). Consequently, the measured ruminal pH can easily be higher than the actual value, and thus the level of SARA can be underestimated (Garrett et al., 1999; Enemark et al., 2003).

2. Methods using indwelling pH data loggers

The first indwelling pH sensors that measured via a ruminal cannula were used by Johnson and Sutton (1968). Inserting a pH probe directly into the rumen digesta and recording the ruminal pH in real time is appropriate for evaluating fluctuations of rumen pH (Dado and Allen, 1993). The indwelling rumen pH device is used with a built-in data logger and wireless communication technology (Penner et al., 2006; Abdela, 2016).

Recent studies have used indwelling pH probes placed into the rumen (Duffield et al., 2004; Strabel et al., 2007) or the reticulum (Sato, 2012b; Mottram, 2016) for continuous measurements. Indwelling pH data logger methods allow diurnal recording (Duffield et al., 2004; Gasteiner et al., 2009), but for data collection the chip has to be removed via a rumen cannula (Dado and Allen, 1993; Penner et al., 2007) or it has to be fixed onto the animal, when the data are transmitted to an external unit via a cable (Krause and Oetzel, 2006).

2a. Indwelling intraruminal sensor

The indwelling probe linked to an external monitor attached to the cow's back represented a great advantage by allowing the free movement of cows during recording (Al Zahal et al., 2007). The pH probe is placed into a metal or plastic tube to be protected but its perforated ending allows the sensor bulb to be in contact with the ruminal fluid. The sensor is weighted to sink into the ventral rumen, and it is inserted into the rumen through a ruminal cannula (Penner et al., 2006). The disadvantages of the indwelling intraruminal sensor come from the fact that it can only be used on fistulated animals which makes it impracticable for field use; the ruminal cannula represents a risk for animal health and an animal welfare concern; in addition, the animal must be tied in a stall for its use.

2b. Indwelling wireless intraruminal sensor

Numerous specific wireless intraruminal sensors have been developed over the past decade. All systems are composed of the indwelling intraruminal wireless sensor (with a pH probe calibrated with reference solution, a processing unit that reads and registers the pH signal, a converter that converts the pH signal to radiofrequency, and a battery for autonomous measurement) and the receiver and the operating system. Data can be transmitted to the operating system either in real time or with a short delay (Mottram et al., 2008).

Due to the correlation between the measurement results obtained using wireless boluses and those obtained with calibrated laboratory pH probes, wireless ruminal boluses are reliable (Penner et al., 2009). The ruminal bolus is inserted into the rumen by the oral route. The location of the bolus during the examination is the key element in measuring and transmitting the right data.

By spot sampling the rumen fluid with cannulation in the bolus area, there is a close relationship between the pH measured by the bolus and the spot sampling in the known area (Mottram et al., 2008). To allow the bolus to sink down into the desired ventral sac of the rumen, it must reach an average density of 2.3 g/cm (Fallon and Rogers, 2001), which means about 300 g. Because of the reticuloruminal contraction cycle, the ruminal probe should be pushed further to the reticulum (Enemark et al., 2003; Li et al., 2013). Some authors (Khol-Parisini et al., 2015; Kovács et al., 2017) have reported the reticuloruminal pH, while others distinguish between the ruminal and the reticular pH (Falk et al., 2016). Since the ruminal and reticular pH values have been found to differ (Falk et al., 2016), localization must be considered when developing the diagnostic limit.

In a recent study, authors suggested that ruminal pH indicators in long-term SARA detection should be refined based on individual reticuloruminal pH kinetics, as commonly used pH SARA indicators were not able to differentiate SARA syndrome due to the high interindividual variability and calibration drift (0.025 pH units/week) and some high frequency noise which may be detected as a false negative pH peak (Villot et al., 2018). With corrections of the

absolute pH value with these factors, the prediction of SARA might be improved significantly. Normalized kinetics were smoothed using a 180-min moving average resulting in filtered normalized kinetics. Modelling the effects of a high- vs. low-starch diet was more accurate using these normalized pH indicators as they increased significantly (Villot et al., 2018).

3. Other diagnostic methods

3a. Manure evaluation

Manure observation can be used for the evaluation of rumen function (Hall, 2007). Due to high-grain diets, more nutrients can reach the hindgut and excessive fermentation in the hindgut can change the appearance of the manure. In normal rumen function, only a few feed particles up to a half inch (1.27 cm) should be observed in the manure. Watery and foamy manure indicates abnormal fermentation in the hindgut (Li et al., 2013; Abdela, 2016).

3b. Fecal LPS

SARA in dairy cows is associated with the increase of LPS endotoxin concentration originating from Gram-negative bacteria in the faeces (Li et al., 2012). Dairy farms with low dietary NDF have almost twice the faecal LPS concentration than farms with a high dietary NDF (Plaizier et al., 2008; Abdela, 2016).

3c. Measurement of rumen mucosa thickness

Preliminary studies suggest that linear ultrasound probes commonly used by veterinary practitioners are promising for the detection of SARA. Neubauer et al. (2018) combined the continuous measurement of the rumen mucosa thickness measurements by transabdominal ultrasound with the lactation number of the individual cows. Authors found this method appropriate for SARA diagnosis in dairy cows (with increased values of rumen mucosa thickness in cases of decreased reticuloruminal pH).

3d. Blood acid–base analysis

Since SARA is characterized by an acid overload in the rumen, it may cause an acid–base imbalance in the blood. Therefore, blood acid–base analysis may be helpful in the diagnosis of SARA. Since various decreases of blood pH and bicarbonate or changes in the base excess were observed during SARA (Brown et al., 2000; Bevans et al., 2005), blood acid–base analysis has proven to be a valuable tool in the diagnosis of acidosis, while being less invasive than rumen pH analysis (Gianesella et al., 2010). Kleen et al. (2003) indicated that blood pH and base excess might be useful in the diagnosis of SARA, while Gianasella et al. (2010) found that cows at a substantial risk of SARA had relatively high pCO_2, low pO_2, and low blood pH.

Conclusions

Although pH changes in the rumen have no diagnostic value for SARA due to local variation, the local difference from the physiological standard pH value can be informative. Several invasive and non-invasive methods are available for diagnosing SARA. Based on the literature, indirect parameters such as the observation of feeding activity, monitoring of milk, faecal and blood variables, together with novel technologies might provide advantages in SARA diagnosis. However, limited specificity and sensitivity do not allow the reliable identification of cows at risk of SARA in practice. Detection of the signs of SARA using wireless indwelling systems should be a key strategic tool in dairy herd monitoring in combination with other non-invasive diagnostic tools;

however, its cost is a limitation to its routine use.

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Subauktna acidoza buraga u mliječnih krava – fiziološko značenje, čimbenici rizika i dijagnostičke metode

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Prema najnovijim istraživanjima, pojavnost subakutne acidoze buraga (SARA) je oko 20 % u mliječnih krava u ranoj i srednjoj laktaciji, a prouzroči gubitke od približno 500 milijuna do 1 milijarde američkih dolara godišnje u SAD. Dijagnostika SARA je još uvijek problematična zbog nedostatka patognomoničnih karakteristika te kašnjenja pojavnosti određenih kliničkih znakova. Stoga je SARA i dalje zanemarena pa čak i neprepoznata u mnogim stadima mliječnih krava. SARA karakteriziraju dnevne epizode niskog pH buraga, kada se pH vrijednost kreće u rasponu od 5,2 do 6,0 kroz duže vrijeme, zbog nakupljanja nižih masnih kiselina i nedovoljnog puferiranja sadržaja buraga. Uzroci SARA povezani su s obrocima bogatim koncentratima, kao što je pretjerano davanje nestrukturnih ugljikohidrata i visoko probavljive voluminozne krme s nedovoljno grube voluminoze. SARA je povezana i s upalom različitih tkiva i organa u mliječnih krava, a njezine dugotrajne posljedice uključuju promjenjiv unos hrane, smanjenu probavu vlakana, smanjenu proizvodnju mlijeka i mliječne masti, oštećenja probavnog sustava, proljeva, laminitis, apscesi na jetri i šepavost. Cilj ovog preglednog rada je sažeti trenutno dostupne podatke o fiziološkim aspektima, činiteljima rizika, pojavnosti i potencijalnim indikatorima SARA u mliječnih krava. Prema trenutnoj literaturi jedine terenske metode za dijagnostiku SARA uključuju ruminocentezu i korištenje sonde buraga. Danas postoje poboljšane terenske dijagnostičke metode za kontinuirano mjerenje retikoruminalnog pH i lakšu dijagnostiku SARA. Bežične sonde koje kontinuirano mjere pH sadržaja buraga trebale bi postati sve značajnija dijagnostička metoda u skorijoj budućnosti.

Ključne riječi: *subakutna acidoza buraga, dijagnoza, ruminocenteza, bežične sonde buraga, mliječne krave*